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Psychological Monographs: General and Applied

A Factor-Analytic Study of Planning Abilities

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I. INTRODUCTION

THIS STUDY is the fifth in a series of investigations designed to explore abilities considered to be important in the successful performance of high-level personnel.[2] For the first four studies in the series see (3, 6, 10, 13). The purpose of this study was to isolate and define the abilities involved in planning performances. We were especially interested in planning as it enters into the activities of supervisory, military, and research personnel. It is in the planning performances of these groups that we have looked for clues as to hypotheses of ability requirements that are common in almost any kind of planning regardless of vocational context.

There is little psychological literature bearing directly on planning; the most useful were the reports of previous factor analyses. A *planning* factor was found in the AAF Aviation Psychology Research Program but was not clear-cut as a very general or fundamental ability of planning or foresight (9). Analyses were made of two special AAF batteries of foresight-and-planning tests, both of which included a small number of planning tests plus reference tests. The planning tests helped to define two new factors: a *planning* factor and an *integration* factor. The agreement between the two analyses was not very strong with respect to the new factors.

Two alternative hypotheses were advanced in Report No. 5 of the *AAF Psychology Program Research Reports* (9) to explain the nature of the *planning* factor. One hypothesis was that it might represent a type of ideational fluency, i.e., with the idea that the man who can think of more solutions per unit of time would have an advantage with some of these tests. This explanation does not hold very well, since the production of ideas is no more important for performance on the tests that were loaded on the factor than for other tests that did not have significant loadings. The second hypothesis is

[1] Now at System Development Corporation (formerly System Development Division of the RAND Corporation).

[2] Under Contract N6onr-23810 with the Office of Naval Research. The ideas expressed in this paper are our own and do not necessarily represent the opinions of the Office of Naval Research. Reproduction in whole or in part is permitted for any purpose of the United States Government. Of the authors of this paper, J. P. Guilford is responsible investigator and director of the project, P. R. Christensen is assistant director, and R. M. Berger was in direct charge of this particular study. For a fuller discussion of this study see references no. 2, 4, and 5.

P. R. Merrifield participated in the development of the ordering hypothesis and contributed greatly to the construction of items and the devising of scoring methods.

We are indebted to the following persons in the University of Southern California departments indicated for making available to us classes for preliminary experimental testing: Dr. Constance Lovell, Psychology; Dr. E. C. McDonagh, Sociology; Dr. D. W. Lefever and Mr. R. A. Jones, School of Education. In addition we gratefully acknowledge permission for test use and/or adaptation by the following authors and publishers: R. L. Thorndike (test 5); R. B. Cattell and the Psychological Corporation (test 6); L. G. Humphreys (tests 9, 12, 33, 34, 35); D. C. Adkins and Press Features, Inc. (test 21); D. C. Adkins and the AGO (test 22); and Irving Lorge (test 32). Tests 37, 39, 49, 50, and 52 were parts of the Aircrew Classification Battery.

We are very much indebted to the staff of the Personnel Research Laboratory, HRRC, Lackland AFB, Texas, for making the testing possible and for the expert administration of a long and demanding test battery. In particular we wish to thank Dr. Lloyd G. Humphreys, Director of Research, Dr. J. W. Bowles, Technical Aide, and the military personnel who acted as test administrators and proctors.

that some form of visualization different from the manipulation type is required in tests of planning. Convincing evidence for this hypothesis is also lacking.

In an analysis of the AAF Sheppard Field battery of tests, Guilford, Fruchter, and Zimmerman (7) found a planning factor, which they labeled "planning speed." Most of the tests that appeared loaded on this factor had been analyzed in AAF studies discussed above. Due to the inclusion of a large number of planning tests, the investigators felt the *planning speed* factor was probably more stable than the *planning* factor found in the previous AAF analyses. The new factor was termed *planning speed,* since the emphasis had shifted to tests in which speed plays a more important role.

Lucas and French included several of the AAF planning and integration tests in a recent study (11). An integration factor corresponding to the AAF *integration III* was tentatively identified, although the planning tests did not show up on the factor as they did in AAF analyses. The presence of two planning tests on another factor suggested it might be a planning factor. The evidence is not clear, however, since the loadings and communalities tend to be very low.

II. Hypotheses

Planning was conceived not as a unitary psychological function but as a term to cover certain classes of activities. On the basis of our considerations of planning activities and previous studies, six major hypotheses were developed concerning the abilities involved. Four were formulated in terms of classes of activities involved in the various stages of planning. These were: *orientation,* hypothesized as an ability to see an order or trend in a mass of information and to recognize the pertinent variables operating in a situation; *prediction,* the ability to see beyond the material given; *elaboration,* the ability to produce ideas or representations of ideas that contribute to the development of plans; and *ordering,* the ability to arrange bits of information into a meaningful series. Two additional hypotheses were constructed pertaining to the qualitative aspects of planning. They were: ***ingenuity,*** the ability to find new and different methods of accomplishing a task; and *evaluation,* the ability to detect limitations in plans and to determine relative importance of variables.

Each major hypothesis indicates an expected primary thinking ability. Each subhypothesis reflects a specific feature or variation or alternative conception of the primary-ability dimension. These hypotheses and subhypotheses have served as the logical base for what was recognized as a continuing research program in which this study is an exploratory investigation. From an operational point of view, the subhypotheses served as starting points for test ideas.

The complete list of hypotheses, subhypotheses, and the tests (by number) designed to measure them follows:

1. Orientation
   - *a.* Sensitivity to order: seeing an order or trend in a relatively ambiguous situation (tests 1-3, see Section III).
   - *b.* Recognition of variables: awareness of the pertinent variables operating in a situation (tests 4–5).
2. Prediction
   - *a.* Extrapolation: seeing the effects of a spatial or temporal extension of a present trend (tests 6–8).
   - *b.* Foresight: relating what is given to what lies ahead (tests 9–12).
3. Elaboration
   - *a.* Specification: specifying the necessary details (tests 13–15).
   - *b.* Production of alternate methods: finding different arrangements of the same material that will fulfill the requirements of an adequate solution (tests 16–17).
   - *c.* Symbolization: producing adequate representations of ideas (tests 18–19).
4. Ordering
   - *a.* Temporal ordering: arranging steps in a time sequence (tests 20–22).
   - *b.* Hierarchical ordering: arranging subject matter according to class and subclass (tests 23–25).
5. Ingenuity
   - *a.* New methods: finding new or uncommon procedures (tests 26–27).
   - *b.* New applications: adapting methods to new situations (test 28).

6. Evaluation
   a. Importance of variables: determining relative importance of variables (tests 29–30).
   b. Seeing deficiencies: detecting the shortcomings of a proposed procedure (test 31).

Reference factors (previously known factors expected) are: *planning* (AAF analyses), *integration III, verbal comprehension, general reasoning, logical evaluation, originality, ideational fluency, associational fluency, adaptive flexibility, eduction of conceptual relations, judgment, visualization, symbol manipulation,* and *numerical facility.*

Included in the battery is a test that is necessarily complex in that it requires the examinees to devise a complete plan. The test is an adaptation of Lorge's Planning Skills test. A detailed account is given of a military situation in which there are problems of morale and leadership; the examinee is required to write down the steps in a plan of his own making that will improve the situation. Further description of the test will be given in section III. It should be informative to note to what extent a score on a test of general planning will load on the various factors that emerge in the analysis.

III. The Test Battery

Several considerations influenced the kinds of new tests constructed and kinds of scores used:

1. Many of the tests require completion-type answers. It was felt that since some planning activities are necessarily productive, the measures of the abilities associated would best be made on the basis of productive efforts of the examinee.
2. An attempt was made to develop tests which, although of the completion type, might be scored objectively. A minimum requirement for those to be scored subjectively was that it was possible to develop a reasonably reliable score.
3. Separately timed parts were constructed where possible to permit the computation of meaningful alternate-forms reliability estimates.
4. An effort was made to construct unique tests where possible, that is, tests of one common factor, except in a few cases where the task presented is of necessity complex.
5. Where possible, simple tasks and situations were used in order to minimize variances due to differences in personal experience.

Most of the new or adapted tests that were to serve as experimental tests were pretested on groups of college students in order to determine adequate lengths, time limits, and instructions. Information derived from this pretesting was used in rejecting some of the tests and in revising and improving the 31 experimental tests to be included in the final battery along with 16 reference tests. In addition, several Air Force test scores from the classification battery were included in the analysis, also for reference.

All tests included in the analysis are described in the next section. For convenience, they are arranged in the order of the hypotheses rather than in the order of administration. For each test, the nature of the task is stated briefly, and wherever possible a sample item is given.

It should be noted that the sample items are transparently easy, since they were used as part of the test instructions for orientation. With respect to difficulty, then, the sample items are not typical of the items in the test proper.

The number of separately timed parts, the number of items per part, and the working time are indicated. Since the scoring procedure for many of the tests, especially those requiring subjective evaluations of completion responses, may be of interest, a summary of the scoring protocol is also given for most of such tests.

The code numbers of the experimental tests and some reference tests developed at this laboratory indicate the following information: The first letter—P, R, C, or E—indicates planning, reasoning, creativity, or evaluation, respectively. The second letter stands for a specific hypothe-

sis; in the case of planning, R means orientation, X means prediction, E means elaboration, O means ordering, I means ingenuity, and J means evaluation. Next comes the number of the test under the hypothesis, usually in order of the subhypothesis listed: 01, 02, etc. The last letter indicates the form of the test, A meaning the first form, B the second form, etc. Several experimental tests are uncoded; these are tests adopted or only slightly adapted from other sources.

A. Description of Experimental Tests

1. Orientation

a. Sensitivity to Order

Test 1. Matrix Order–PRO1A. Each item is a 3 × 3 matrix of words. *E* (the examinee) is required to draw a straight line through the sequence of three words that are in the most meaningful order. The line may be drawn through any one of three columns, any one of three rows, or either of two diagonals. In addition, the direction of the order is indicated by arrowheads. An arrowhead at one end shows the temporal order of the sequence and arrowheads at both ends of the line signify a spatial or logical relationship that can go either way (see Fig. 1).

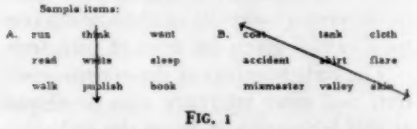

Fig. 1

An order in time is found in sample A. Order in space is found in the diagonal of sample B. The double arrow in sample B indicates that the sequence "skin-shirt-coat" is as logical an order as "coat-shirt-skin."

Scoring: An item is counted correct only when both the correct line is drawn and the correct placement of the arrowhead is made. The total score is the number of items correctly marked.

Parts, 2; items per part, 15; working time, 18 minutes; maximum score (highest possible score), 30.

Test 2. Seeing Trends–RIO6A. Each item consists of a group of words whose arrangement is not entirely uniform. *E* attempts to discover a trend from left to right and writes his description of the trend below the item.

Sample items:

A. mouse rat lion pig cow horse elephant
Answer: *Animals become larger.*

B. century year decade day week second minute
Answer: *Time unit becomes smaller.*

Note that in both items several reversals of the trend occur between words taken as pairs and it is necessary to look beyond adjacent words for the predominant trend.

Scoring: Total score is the number of correctly marked items. Only one kind of response is keyed for each item. In some cases responses worded differently than the keyed ones are acceptable if the meanings are close or if the responses are negatively worded.

Parts, 2; items per part, 10; working time, 10 minutes; maximum score, 20.

Test 3. Sensitivity to Order–PRO2A. Each item consists of 5 words that are ordered in some way. Some of the items present the words in the right order, others have one word out of order. If the arrangement as given is correct, *E* marks a plus sign. If the words are not in their best order *E* is required to circle the word that is out of place and to put a

check to show where that word belongs in the group (see Fig. 2).

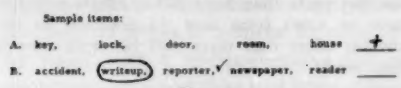

FIG. 2

In sample item *A* the objects are in good order. In sample item *B* the arrangement is not as good as it might be, since the presence of a reporter is usually necessary before the write-up of an accident can be made. "Write-up" is circled and a check indicates that it belongs between reporter and newspaper.

Scoring: Only the items in which some change is to be indicated in the order are scored. The presence of correctly arranged items that the examinee is required to mark with a "plus" serves to keep the examinee from indicating changes in other items that also appear to be properly arranged to him. The items that are scored must have the appropriate word circled and the check correctly placed in order to receive credit. The total score is the number right.

Parts, 2; items per part, 15; working time, 8 minutes; maximum score, 18.

b. Recognition of Variables

Test 4. Pertinent Questions—PRO3A. *E* is presented with a number of conflict situations in which additional information would be required for making a choice. *E* is asked to write four questions, the answers to which would serve as a basis for making a decision.

Sample item:

A student who has just graduated from college is offered positions in two different parts of the country. What four questions have to be considered in making a choice?

Possible answers: What would the work involve in the two jobs? What salaries would be paid? In what places are the jobs? What are the relative opportunities for the future?

Other questions may be acceptable but they may not repeat previous questions and they must refer to different aspects of the problem.

Scoring: One point is given for each response that refers to a separate aspect of the problem. The total score is the number of responses credited.

Parts, 2; items per part, 4; working time, 12 minutes; maximum score, 32.

Test 5. Awareness of Variables—PRO4A. This is a test developed by the Human Resources Research Laboratories at Bolling AFB. A problem is presented in which some decision is needed. Accompanying the problem are a number of statements of facts that may be pertinent to the problem. *E*'s task is to select a specified number of facts that seem most important in reaching a decision.

Sample item:

You are driving from Middleton to Warrensburg. You have plenty of time for the trip. There are two possible routes: Route A and Route B. Which would be better to take?

A. Route A is 105 miles long and Route B is 115 miles long.
B. Route A goes through 5 small cities on the way, while Route B goes through 3 somewhat larger cities.
C. Route A has 10 miles of road under construction, with dirt surface and sections of one-way traffic.
D. Route B is mostly winding, bumpy macadam, while Route A is mostly 4-strip concrete.
E. Route A goes north of Lake Winepaw, while Route B goes south of the lake.

Which two facts are the most important to consider in deciding which route to take? Circle the letters preceding the two statements selected.

The best answers are generally agreed to be *C* and *D*.

In the test itself, each problem has 15 facts under it, and *E* is to select the *five* facts that are most important.

Scoring: Expert opinion was used in determining the "most important" facts for each of the four problems; the facts

on which most experts agreed constituted the provisional key. Scores were obtained using this key and the results were subjected to item analysis. This led to certain minor modifications resulting in the final key. The number of "important" facts in this final key varies from 4 to 5, depending on the empirical results. In scoring, a weight of 1 is given to each agreement with the key. The total score is the number of such agreements.

Parts, 4; items per part, 1; elements per item, 15; working time, 12 minutes; maximum score, 18.

2. *Prediction*

a. Extrapolation

Test 6. Series. This test is an adaptation from the items included in a part of R. B. Cattell's *A Culture-Free Test*. Each item consists of a series of figures, which are varied in some systematic fashion. *E* has to select the figure that goes next in the series by choosing among six given alternatives (see Fig. 3).

FIG. 3

Scoring: Score is the number of items correctly marked.

Parts, 2; items per part, Part 1–7, Part 2–8; working time, 5½ minutes; maximum score, 15.

Test 7. Effects—PXO1A. Given a statement of some present-day trend, *E* attempts to predict what the nature of the effects of this trend will be at a specified future time. Each item consists of the statement of a trend and provides room for writing down four possible effects. The trends given are realistic and cover many different areas in which there is common experience.

Sample item:

A. There have been more girls born in the last five years than boys. What effects will this have 20 years from now (in addition to the obvious effect that there will be more women than men)?

Possible answers: *More unmarried women than unmarried men. More rivalry among women for husbands. More women would take up career work. Agitation to allow polygamous marriage.*

Scoring: Four responses can be given to each item and each response is weighted either 0, 1, or 2. If the response is a duplication of a previously given one or is not a possible effect of the trend given, it is weighted zero. Effects that are possible are weighted 1; an additional weight of 1, or a total response weight of 2, is allowed if the effect is less obvious or is somewhat indirect. The total score is the sum of the weights.

Parts, 2; items per part, 5; working time, 16 minutes; maximum score, 80.

Test 8. Consequences (Remoteness)—CFO6A. For each item in this test a change of an unusual nature is imposed which would disrupt the normal state of affairs. *E* is required to list as many different consequences or results of these changes as he can.

Sample item:

What would happen if all national and local laws were suddenly abolished?

Possible answers: *People would no longer get parking tickets. There would be more killing. No more taxes.*

Scoring: There are two scores derived from this test: a low-quality score and a remoteness score. For the low-quality score the number of direct responses is determined. Direct responses are those that describe direct or immediate consequences of the given changes. The low-quality score is used as a measure of *ideational fluency* (see test 44). The remoteness score is the one used here as a meas-

ure of *prediction*. The score is based on the number of indirect or remote consequences listed. The individual responses are rated as direct or remote by comparing them with a comprehensive list of model consequences that had been shown to be reliably weighted in a previous scoring for the creativity analysis. Every response is thus scored either 1 or 0 for remoteness. The total score is the sum of the weights.

Parts, 4; items per part, 1; working time, 8 minutes; maximum score, unrestricted (U).

b. Foresight

Test 9. Competitive Planning. This is an Air Force test modified slightly for purposes of this study. The test is based on the familiar "completion-of-squares" game. Each of two hypothetical opponents (Black and White) tries to complete as many squares as possible in figures that are incomplete. *E* has to plan the moves for both opponents so that each achieves the maximum number of squares possible. Black always makes the first move, filling in one side of an incomplete square. Each time Black or White completes a square, he has to make one additional move. *E* must look ahead in many cases in order to see that a move giving an immediate gain should be passed over in favor of one making possible greater gains for future moves.

This is an answer-sheet test and an answer legend provides five alternative outcomes for the number of squares completed by the opponents, Black and White (see Fig. 4).

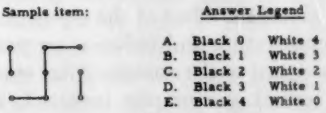

FIG. 4

Making the best moves possible for their individual interests, Black and White complete this sample problem in the following manner: as always, the first move is made by Black. No matter which side Black fills in, White is able to complete two squares immediately. After completing the second square, White fills in a side of one of the remaining squares. This enables Black to complete the remaining squares so that the final result becomes two squares for Black and two squares for White. The answer marked, therefore, should be C.

Scoring: The score is the number of items right minus the number wrong divided by four $\left(R - \frac{W}{4}\right)$.

Parts, 2; items per part, 20; working time, 20 minutes; maximum score, 40.

Test 10. Symbol Grouping—PXO2A. Each item consists of a line of X's, —'s, and O's presented in a scrambled order. The task is to make successive moves of groups of one or more adjacent symbols to achieve the correct order. The desired order for all items is first all the X's, next all the —'s, and last all the O's. The score depends not only on finding a solution but also on making as few moves as possible. Since there are a variety of ways of getting to the correct order, foresight is hypothesized to be demonstrated when the most economical procedure is adopted. *E* indicates each move by circling the symbol or symbols to be moved and placing a checkmark at the place they are to go. This is repeated for each new arrangement resulting until the solution is reached (see Fig. 5).

Scoring: A weight of 2 is given when the solution is reached in the minimum number of steps, and a weight of 1 is given for the minimum number of steps plus one more step. Two steps or more

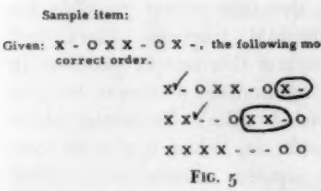

FIG. 5

beyond the minimum is felt to indicate little or no foresight and is therefore given no credit. Unsolved and unattempted problems are also not credited. The total score is the sum of the weighted item scores.

Parts, 2; items per part, 8; working time, 10 minutes; maximum score, 32.

Test 11. Contingencies–PXO3A. In each item an object is named that is to be considered in connection with a given situation. *E*'s task is to state a possible condition that might require the use of a given object in that situation. Four objects are presented with each item in the test.

Sample item:

Sally and Jane are going out to a farm to pick berries for the day. Their pay will be half the berries they pick. Included in the things they will take are the objects listed below. For each object, state a condition or circumstance that may arise requiring the use of that object. (Do not merely give the use of the object, but write *why* it might come into use.)

Ointment *If bitten by insects or scratched.*
Pins *For possible rips in the clothes.*

Scoring: Each written response is scored as either acceptable or unacceptable. A response is acceptable if a plausible condition is given that might arise and require the use of the object. The total score is the number of acceptable responses.

Parts, 2; items per part, 20; working time, 12 minutes; maximum score, 40.

Test 12. Route Planning–CI411AX. This is an adaptation of an Air Force test. For each item *E* must trace a path from the corner of a printed maze to a goal box in its center. There are four item numbers, one at each corner of the maze, that serve as starting points. The task is to locate the one point through which one must pass in going to the goal. Letters mark the points on the various routes between the starting point and the goal. When *E* finds the one letter which he must pass through in order to reach the goal he marks the letter on the special answer sheet provided (see Fig. 6).

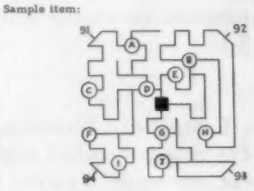

FIG. 6

In going from 91 to the goal, you may pass through either A or C; however, you must pass through D; therefore, D is the right answer. Answers for other items are: 92–B, 93–G, and 94–D.

Scoring: $R - W/2$.

Parts, 5; items per part, 8; working time, 17 minutes; maximum scores, 40.

3. *Elaboration*

a. Specification

Test 13. Planning Skills II–PEO2A. This test is an adaptation of Irving Lorge's Planning Skills Test (the latter is employed as a test of general planning and described as test 32). *E* is allowed five minutes to read a description of the conditions prevailing at some hypothetical military, weather-station outpost in the Arctic. The conditions for the most part entail the effect of the rigors of Arctic temperature and isolation on personnel assigned to the stations. After reading the several paragraphs involved, *E* is given the signal to turn to the first part of the test, which requires that he write

as detailed a plan as possible on some given aspect of the problem situation. For the second half of the test another particular aspect of the problem situation is given and *E* is to write down all the details necessary for coping with that part of the problem.

Scoring: Each detail listed, if specific enough, is given credit. The total score is the number of acceptable details.

Parts, 2; items per part, 1; working time, 16 minutes; maximum score, U.

Test 14. Planning Elaboration—PEO1A. Each part consists of a statement in which some plan of activity is briefly outlined. *E*'s task is to fill in as many of the details as he feels necessary to make the plan work. Each point or detail specified is written on a separate line.

Scoring: The total score is the number of details specified.

Parts, 2; items per part, 1; working time, 16 minutes; maximum score, U.

Test 15. Figure Production—PEO3A. Each item in this test consists of markings of one type or another. The markings as given have no particular meaning. *E*'s task is to add to what is given as much as he feels necessary to produce a complete and meaningful figure. *E* can draw any figure he wishes as long as the given markings are definitely incorporated in what he makes (see Fig. 7).

FIG. 7

Scoring: A total of 140 sample responses to the stimuli were categorized by three raters into a 5-point equal-interval scale of "elaborateness." The responses on which all raters agreed were used as models for their respective categories. Categories were assigned weights from 0 (least elaboration) to 4 (greatest elaboration). The remaining responses were weighted according to the category in which they were placed by a qualified rater. Score is the sum of the weights over all responses.

Parts, 3; items per part, 4; working time, 9 minutes; maximum score, 48.

b. Production of Alternate Methods

Test 16. Alternate Methods—PEO4A. In each part a task is described that may be carried out in a number of nearly equally effective ways. *E* attempts to write down as many as six different ways of distributing the work and assigning personnel in order to accomplish the task.

Sample item:

A house located near a stream is on fire. Twenty men, each carrying a bucket, arrive to help put out the fire. The house is about 20 yards from the stream. In how many ways could you organize this bucket brigade to deal with the fire?

Possible answers: *a. Form a line of 20 men; the first man fills a bucket and it is passed from man to man; the last man throws the water on the fire and runs back with the empty bucket.*

b. Form two lines of 10 men. The filled buckets are passed up one line and the empty ones back down the other.

c. Assign 5 men to fill the buckets, 10 men to run with the buckets, and 5 men to throw the water where it is needed.

Scoring: In order to be counted as an acceptable response, each method listed must be practicable, employ all or most of the given material, and be in some way different from the other methods produced. The total score for the four items is the number of acceptable responses.

Parts, 4; items per part, 1; working time, 14 minutes; maximum score, 24.

Test 17. Match Problems II—PEO5A. This test is a varied form of the Match Problems test to be described in a later section (test 46). These tests utilize the match-stick problems in which groups of matches are laid out to form patterns of squares or triangles. *E* must find a way

of taking away a specified number of matches to leave a certain number of squares or triangles remaining. In test 17 *E* has to find several different solutions for each problem. That is, different *patterns* of matches must be removed to leave the specified number of squares or triangles. Three or four different ways of solving each problem are possible (see Fig. 8).

FIG. 8

The matches to be taken away are indicated by crossing them out with short heavy marks. In the sample item above the solution is reached by removing 5 matches in the four different patterns indicated.

Scoring: Credit is given for each correct, different pattern. The total score is the number of acceptable solutions.

Parts, 2; items per part, 5; working time, 20 minutes; maximum score, 38.

c. Symbolization

Test 18. Symbol Production–PEO6A. In this test *E* must produce symbols of his own invention to represent given activities and objects. In order to be acceptable the symbol produced must be a meaningful one for the action and the thing presented (see Fig. 9).

E is instructed not to draw stick figures or cartoon figures performing the acts but to try to symbolize the actions themselves.

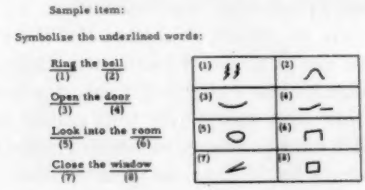

FIG. 9

Scoring: Obviously a wide variety of symbols may be produced in this test. A response is judged as an acceptable symbol if some relation, however remote, can be seen between it and the object or action to be symbolized. Cartoon figures are not acceptable unless there is additional material that can stand alone as a proper symbol. The same symbol used for different items is scored only on its first occurrence. The total score is the number of acceptable symbols.

Parts, 2; items per part, Part 1–31, Part 2–30; working time, 10 minutes; maximum score, 61.

Test 19. Line Drawing–PEO7A. This is a test developed by J. P. and Ruth B. Guilford as a prognostic test of creativity in design (7). *E* is given a list of adjectives for each of which he is to draw a simple line that expresses the meaning of the adjective. Any kind of line may be drawn, such as straight, curved, in the form of a wave, or an angular pattern. The test is not a speeded one; everyone is allowed to finish.

Scoring: Each line is scored for *form*, *direction*, and *type*. Lines are described as to *form* in four ways: wave, curve, angle, and straight line. The *direction* is scored in three ways: horizontal, up (upward slant), and down (downward slant). The *type* may be heavy, medium, or light. This classification gives ten categories within which to classify each line in the test, i.e., four for *form*, three for *direction*, and three for *type*. Using the responses from half of the examinee group, the frequency with which each line fell into each of the 10 categories was tabulated. The frequencies were translated into sigma values above and below the mean and these values, adjusted by a shift of zero point to make them all positive, were used as the weights. The score

for each line is the sum of the weights for form, direction, and type. The total test score is the sum of the line scores.

Parts, 1; items per part, 24; working time, 10 minutes; maximum score, 242.

4. Ordering

a. Temporal Ordering

Test 20. Temporal Ordering—POO1A. In this test *E* is given a short description of a project and a list of some of the steps involved in the project. The steps are not in the best time order as listed. Following the list are questions that concern the proper order of the steps in different parts of the list. *E* indicates the answers by filling in the letters corresponding to the appropriate steps.

Sample item:

Fixing a Flat Tire:

While you are driving along a busy highway late one dark night, your right rear tire goes flat. The steps described below are some of those to be performed.

a. Set out flares that had been stored in glove compartment.
b. Tighten nuts on wheel.
c. Block wheels so car won't roll.
d. Raise car with bumper-jack.
e. Replace flat with spare.
f. Unlock the trunk to get wheel blocks.
g. Take bumper-jack out of trunk.

In the blanks left in the following statements, enter the letters indicating the appropriate step or steps.

1. The steps that should precede step *d* include: *a, c, f, g.*
2. The first two steps of this plan, in order, are: *a, f.*
3. The last step of this plan should be step *b.*

Scoring: The examinee had to decide, in general, which elements preceded and which followed the reference elements for a particular question. A weight of +1 is given each element properly placed. To correct for "padding," against which the examinees were forewarned, a weight of −1 is given each element incorrectly placed. Where the proper order was requested, bonus points are added for responses in which the elements within a response are correctly ordered; points are deducted if the examinee's order is too far from the correct sequence. The score is the sum of the weights over all elements of the responses.

Parts, 4; items per part, 8; working time, 16 minutes; maximum score 75.

Test 21. Picture Arrangement. This is Dorothy C. Adkins' test based on sequences from the comic strip known as "Louie," which has been adapted with the permission of Press Features, Inc. Each item consists of a separate sequence in which the pictures are disarranged. *E* is required to number the pictures to produce what he considers the most sensible order (see Fig. 10).

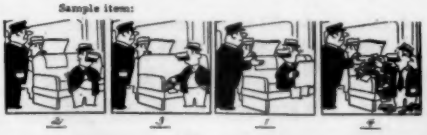

FIG. 10

To show how the pictures should be arranged in order to make sense, a "1" has been written under the picture that should come first, a "2" under the picture that should come second, and so on.

Scoring: The total score is the number of correctly ordered sequences, i.e., items.

Parts, 2; items per part, I–8, II–12; working time, 7 minutes; maximum score, 20.

Test 22. Sentence Order—RPO4B. This was adapted from a test in Dorothy C. Adkins' North Carolina battery of reasoning tests. Each item consists of three sentences, which are to be arranged in a sensible order. *E* indicates the order by numbering the sentences.

Sample item:

2 She bought some food at the market.
3 She returned home and cooked some of the food she had bought.
1 She went to the market.

Scoring: The total score is the number of items in which the sentences are correctly ordered.

Parts, 2; items per part, 10; working time, 6 minutes; maximum score, 20.

b. Hierarchical Ordering

Test 23. Outlining I—POO2A. In this test a series of statements of differing degrees of generality are given and *E*'s task is to arrange the given statements so that the more particular (less general) statements are grouped under the more general statements with which they have most in common. One statement, the most general of all, is to be designated as the title.

Sample item:

A. Cats are useful as mousers.
B. Dogs are fine as guardians.
C. Cows give milk.
D. Animals are useful in a variety of ways.
E. Some pets are useful as well as being enjoyable.
F. Sheep furnish wool.
G. Farm animals are essential to our way of life.

Instructions: Put the letter for each of the statements above in one of the spaces below so as to make the best outline. Use all statements; use each statement only once.

Title *D*
I. *G*
C
F
II. *E*
A
B

In the test proper the context of the hierarchical ordering task involves the characteristics of eggs as a food.

Scoring: Weights are assigned to each element on the basis of its being grouped with the other elements with which it properly belongs and on the basis of its being at the proper level of generality as intended by the constructors of the item. Score is the sum of weights over all elements of the response.

Parts, 1; elements per part, 16; working time, 5 minutes; maximum score, 21.

Test 24. Outlining II—POO2A. This test was administered as Part II of the Outlining Test, for which the description appears above (test 23, Outlining I). The context of the hierarchical ordering task is the planning of a club meeting.

Scoring: See test 23.

Parts, 1; elements per part, 16; working time, 5 minutes; maximum score, 21.

Test 25. Word Matrices—CYO5A. In this test *E* is given several word squares, each of which is composed of three horizontal spaces and three vertical spaces. Two or three of the spaces have already been filled in with words which set the pattern for filling in the rest of the spaces. *E*'s task is to arrange the words given below each square in their proper places so that the words of each row of the square will show the same relationships.

Sample item:

minnow	—	net
—	—	rod
—	—	—

lake, whale, ocean, bass, harpoon, pool.

The proper arrangement is:

minnow	*pool*	net
bass	*lake*	rod
whale	*ocean*	*harpoon*

The pattern in each of the horizontal lines is: type of fish, place it is usually found, and instrument with which it is caught. Each of the vertical columns is arranged so that all the items in each column are of a similar nature. For example, all the items in the first column are names of fish.

Scoring: The total score is the number of matrices in which all words are correctly arranged.

Parts, 1; items per part, 12; working time, 8 minutes; maximum score, 12.

5. *Ingenuity*

a. *New Methods*

Test 26. Unusual Methods—PIO3A. Each item involves a problem which is ordinarily handled in ways that are familiar to everyone; *E*'s task is to find two different and unusual ways of dealing with the problem. One restriction is that the ideas must be usable ones, although they need not be the best or as efficient as the methods already in use.

Sample item:

Suggest two unusual methods for accomplishing the following:

1. Relieve the boredom and fatigue of doing steady work in a business or industry. (The usual method is to have regular breaks during which employees relax or take refreshments).

Possible answers: *Have employees change their tasks every hour.*

Have four-hour shifts instead of eight-hour ones.

Scoring: The total score consists of the number of acceptable responses. In order for a method to be acceptable it must be reasonably practical and not now in use to any appreciable degree.

Parts, 2; items per part, 5; working time, 12 minutes; maximum score, 20.

Test 27. Verifications—PIO2A. Certain phenomena of a physical or a biological nature are presented as facts to be verified. *E*'s task is to find ways of demonstrating these facts. The phenomena are stated in nontechnical terms and satisfactory answers may also be phrased in general terms. For each phenomenon given, *E* is required to write down two different procedures for demonstrating or investigating its validity.

Sample item:

Give two ways of demonstrating that the inside of a large gas flame is not as hot as the outside parts.

Possible answer: *Hold stick in flame—outside parts burn sooner.*

Put thermometer in center of flame and then in outside part—temperature rises faster in second part.

Scoring: The responses are weighted 1 if the general method suggested is an acceptable one. An additional weight of 1 or a total weight of 2 is given to responses that are complete and sound. The total score is the sum of the weights.

Parts, 2; items per part, 5; working time, 20 minutes; maximum score, 40.

b. *New Applications*

Test 28. Procedure Applications—PIO1A. In each part *E* reads a description of a procedure as it is used in accomplishing some particular task. A generalized statement of the procedure then follows in order to make sure that all examinees know the procedural principle that is used. *E* must then find four other tasks or instances where the same procedure would apply.

Sample item:

In chemistry, one of the methods for getting a pure sample of some substance is by successive crystallizations. The substance is first put into solution, then crystallized out. This removes some impurities. The process is repeated several times; each crystallization removes additional impurities until only the pure substance is left. If we think of this method in the general sense of refining or purifying by repeating a process, in what other instances might this method be used?

Possible answers: *Athletic contests in which successive races or matches are used for elimination purposes.*

Spelling bee—people who misspell words drop out until only the best speller remains.

Rinsing clothes—each rinse takes out more soap until none remains.

Scoring: Each procedure has two major aspects. A weight of 2 is given for each response in which both aspects are applicable; a weight of 1 is given for each response in which one is applicable; and a weight of zero is given for each response in which neither aspect is applicable. The total score is the sum of the weights.

Parts, 5; items per part, 1; working time, 12.5 minutes; maximum score, 40.

6. Evaluation

a. Importance of Variables

Test 29. Essential Operations–RPO3B. *E* is provided with a problem and five items of information, one of which is irrelevant to the solution of the problem. *E* indicates which is the irrelevant statement, but does not work the problem. This is a revised form of the test used in previous reasoning studies (3, 6), incorporating certain revisions and additions in the items that were intended to reduce the general-reasoning variance and maximize the judgmental aspects of the test.

Sample item:

Question: How many miles apart will the two boats be when they run out of gas?

A. Boats X and Y each have 5 gallons of fuel.
B. They cruise together toward the same point.
C. Boat X uses 1 gallon of gas going 3 miles.
D. Boat Y uses 2 gallons of gas going 1 mile.
E. Boat Y is twice as heavy as boat X.

The correct answer is *E,* since all the other statements, *A, B, C,* and *D,* provide necessary information for finding the answer to the question. The fact that boat Y is twice as heavy as boat X does not help to answer the question.

Scoring: $R - W/4$.

Parts, 2; items per part, 10; working time, 16 minutes; maximum score, 20.

Test 30. Ranking of Variables–PJO2A. This is an adaptation of the Awareness of Variables test described previously as test 5. Each item consists of a problem in which some decision has to be made and a number of facts that would be of aid in making the decision. *E*'s task in this test is to rank all the facts in order of their relative importance in reaching a decision.

Sample item: The sample item given for test 5 is also used here. This time the statements are ranked in order of importance with 1 indicating the most important and 5 marking the least important fact to consider. The ranks assigned to the statements in the sample item of test 5 are: A–4, B–3, C–2, D–1, E–5.

Scoring: The score for each item is determined from the sum of the differences obtained between the keyed ranks and the ranks assigned by the examinee. By this system, the greatest possible error for each item composed of seven elements is 24 points. (The maximum error would occur, for example, if the assigned rank order is the complete reverse of the keyed order). In order to make the higher scores correspond to the better responses, the sum of the obtained differences for each item is subtracted from 24.

Parts, 2; items per part, 2; working time, 10 minutes; maximum score, 96.

b. Seeing Deficiencies

Test 31. Seeing Deficiencies–PJO1A. In this test *E* is presented with short descriptions of plans or activities that for some reason will not lead to the desired result. *E*'s task is to point out in what way the plan is faulty.

Sample item:

A growing city discovers pressing needs to improve both its streets and its sewer system. After due consideration, the council decides to work on the street improvement program first. What is wrong with this plan?

Possible answer: *Improving streets before sewer system would require the street improvement job be done twice.*

Scoring: One written response is called for in each item and this must correspond in meaning to the keyed answer. No penalty is made for difference in expression of the answer. The total score is the number of items correctly answered.

Parts, 2; items per part, 10; working time, 20 minutes; maximum score, 20.

7. General Planning

Test 32. Planning Skills–PGO1A. This

is a test by Irving Lorge used in studying decision-making. The test requires *E* to devise a complete plan for meeting a practical problem. The problem is similar to some of those encountered by the military in connection with human relations and morale. It involves the effect of the conditions at some hypothetical Air Force base in the Southwest upon the personnel assigned to the base. These conditions include large work load, lack of adequate working facilities, lack of recreational facilities, lack of facilities for dependents and relative isolation of the base. *E*'s task is to recommend a plan of action to solve the problems of low morale and low operating efficiency of the base.

Scoring: The procedure used by Lorge in scoring the test is employed here. Lorge had defined, by means of a content analysis, eight areas in which the responses could be grouped. Within each area there are general statements listed that serve to classify the responses as to quality and determine the weights that should be attached to them. These weights were originally obtained by using a large sample of responses and demonstrating a high agreement among raters in setting the weights. The total score is the sum of the weights.

Parts, 1; items per part, 1; working time, 15 minutes; maximum score, U.

B. Description of Reference Tests

1. Planning (AAF Analyses)

Test 33. Planning Air Maneuvers—CI4O8AX3. This test assumes that *E* is a sky-writing pilot who must plan how to write two adjacent letters by flying the shortest possible path. The starting and finishing positions of the plane are shown, and the sharpest turn that the plane can make is indicated. With this information, and the large letters to be written presented in the test, *E* must select the most direct path in terms of the instructions and indicate the direction he is traveling at each of the numbered points (see Fig. 11).

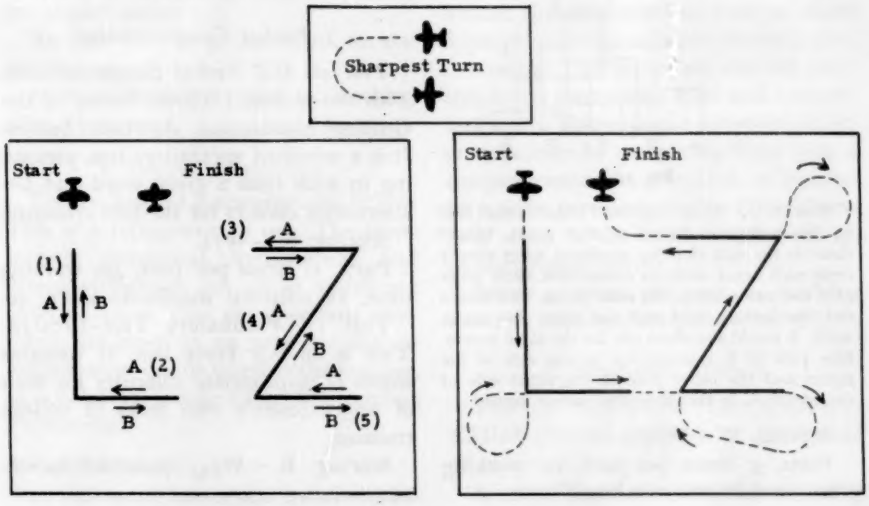

FIG. 11

By referring to the right-hand half of Fig. 11, it can be seen that the correct direction for 1 is A, for 2 is B, 3 is A, 4 is B, and 5 is B.

Scoring: Since the choice of a direction at one of the numbered points affects the direction choice at subsequent decision points in the same pattern, it was decided to score the test on the basis of total patterns. Within each pattern of letters, all choices have to be correct before credit is given. The score is the number of correct patterns.

Parts, 2; items per part, 10; working time, 16 minutes; maximum score, 20.

Test 34. Planning a Circuit—CI4O1. This is another Air Force test of planning. Each item consists of an electrical-circuit diagram with many intersecting wires and with several sets of terminals. *E*'s task is to trace the circuits and determine at which pair of terminals a battery should be placed in order to complete the circuit through a meter (see Fig. 12).

Sample item:

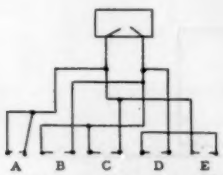

FIG. 12

Dots in the figure represent connections; that is, two wires are joined at that point. Where there is no such dot the insulated wires simply cross each other with no connection. Both poles of A are connected to the same point. This shorts out the battery, and will not make the meter work. B would also short out for the same reason. One pole of C is connected to one side of the meter and the other pole to the other side of the meter. C is therefore the correct answer.

Scoring: $R - W/4$.

Parts, 3; items per part, 12; working time, 12 minutes; maximum score, 36.

2. *Integration III*

Test 35. Code Analysis. Each item consists of a key row of five letters and numbers and below it five other similar rows which constitute the choices. *E*'s task is to select the choice row that contains a given number of symbols of the key row. The numbers 1 to 5 are interchangeable with the letters A to E, respectively. In other words, A is the same as 1, B is the same as 2, etc. The first number, five or less (or its equivalent letter), in the key row indicates the number of the symbols in the key row that the choice row should contain.

Sample items:

I. F E 5 3 A	II. J G 9 A 3
A. H 3 3 3 A	A. 9 7 9 1 3
B. 3 3 5 H 3	B. J 6 1 C 7
C. H C 1 E D	C. G 7 B D 4
D. F 1 E E 3	D. 1 5 D C F
E. 1 3 3 H D	E. 2 7 J E 1

Answers: I–D,
II–C.

Scoring: $R - W/4$.

Parts, 2; items per part, 20; working time, 22 minutes; maximum scores, 40.

3. *Verbal Comprehension*

Test 36. G-Z Verbal Comprehension. This test is Part I (Short Form) of the Guilford-Zimmerman Aptitude Survey. It is a standard vocabulary test, presenting in each item a given word and five alternative choices for the best synonym.

Scoring: $R - W/4$.

Parts, 1; items per part, 40; working time, 12 minutes; maximum score, 40.

Test 37. Vocabulary Test—CI6O4B. This is an Air Force test. It contains words of appropriate difficulty for men of approximately two years of college training.

Scoring: $R - W/4$, converted to stanine value.

Parts, 1; items per part, 150; working time, 15 minutes.

4. *General Reasoning*

Test 38. Ship Destination—RGRO1B. Using a diagram and observing an increasing number of rules, *E* must determine which of three given ports is nearest to a ship in a given position. In addition to the rules of distance, the wind direction must be considered at the start of the test. Later the adequacy of the ports, the ocean current, and the initial heading of the ship must also be taken into account. All these conditions influence distance according to given rules.

Scoring: R − W/2.

Parts, 1; items per part, 15; working time, 15 minutes; maximum score, 15.

Test 39. Arithmetic Reasoning—CI2O6C. This is an Air Force test. The test consists of the setting up of an arithmetic solution to short problems. For example, if a plane uses a given amount of gasoline to fly a given distance, how much gasoline would be required to fly another given distance? In each item the correct response must be selected among five choices given.

Scoring: R −W/4, converted to stanine value.

Parts, 1; items per part, 30; working time, 35 minutes.

5. *Logical Evaluation*

Test 40. Logical Reasoning—RLRO5A. This is a syllogism-type test. The items include categorical, hypothetical, and mixed syllogisms, not all of which are strictly formal. Two, three, or four statements are given in an item and the examinee must decide whether the last one, or conclusion, follows from the preceding statements.

Sample item:

All bombers are heavier than air. All airplanes are heavier than air. Therefore, all bombers are airplanes.

Answer: False.

Scoring: R − W.

Parts, 2; items per part, 15; working time, 10 minutes; maximum score, 30.

Test 41. Inference—RDO3B. Each item presents a statement of fact or opinion and five alternate conclusions. *E* indicates which of these can be drawn with most justification. The items are logically informal.

Sample item:

Most of the trees in the forest are green.

A. There are no yellow trees in the forest.
B. There are some yellow trees in the forest.
C. Some of the trees in the forest are green.
D. Green trees are the tallest in the forest.
E. Pine trees are green.

Answer: *C.*

Scoring: R − W/4.

Parts, 2; items per part, 8; working time, 10 minutes; maximum score, 16.

6. *Originality*

Test 42. Plot Titles (Cleverness)—CFO2B. Four brief story plots are presented. *E* is instructed to write as many appropriate titles as he can for each plot.

Scoring: Two scores are derived from this test; a low-quality score and a cleverness score. The responses are rated clever or nonclever by comparing them with a comprehensive list prepared in connection with previous studies. The cleverness score is the total number of responses judged clever.

Parts, 4; items per part, 1; working time; 12 minutes; maximum score, U.

7. *Ideational Fluency*

Test 43. Plot Titles (Low Quality)—CFO2B. (See no. 42 above for description of test.)

Scoring: Total number of low-quality

responses, i.e., responses not judged as clever.

Test 44. Consequences (Low Quality)—CFO6A. (See no. 8 for description of test.)

Scoring: Total number of low-quality responses.

8. Associational Fluency

Test 45. Controlled Associations II—CAFO2B. Each item consists of a common word for which *E* is to list three synonyms.

Sample item:

ODD: *unusual*
unique
queer

Scoring: Number of responses judged as sufficiently similar to the stimulus words.

Parts, 2; items per part, 10; working time, 6 minutes; maximum score, 60.

9. Adaptive Flexibility

Test 46. Match Problems—CXO3B. In this test groups of matches are laid out to form patterns of squares and triangles. *E*'s task is to take away a certain number of matches and have a certain number of squares or triangles remaining. They must come out even with no extra matches left over (see Fig. 13).

Sample item:

TAKE AWAY 2 MATCHES
AND LEAVE 2 SQUARES

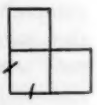

FIG. 13

The correct matches to be taken away are indicated by crossing them out with short heavy marks as has been done in the figure above. Notice that if any other pair of matches is taken away an extra match is left over in addition to the two squares.

Some of the test items are so constructed that they are insolvable if the subject imposes unnecessary restrictions upon himself, e.g., that the squares or triangles be the same size.

Scoring: Number of correct solutions.

Parts, 2; items per part, 9; working time, 12 minutes; maximum score, 18.

Test 47. Sign Changes—CXO4B. This test involves simple numerical operations in which *E* must substitute one arithmetic operation sign for another before performing the operation.

Sample item:

In the following problems, wherever you see: — replace it by ×; + replace it by —.

$3 - 6 = 18$
$6 + 2 = -$
$4 - 3 = -$

The answer for the second item should be *4* and for the third item *12*.

Scoring: Number of correct responses.

Parts, 3; items per part, 8, 16, 16; working time, 2 minutes; maximum score, 32.

10. Eduction of Conceptual Relations

Test 48. Verbal Analogies I—RCRO1C. This is a standard verbal-analogies form of test. The only new idea is an attempt to make the relationship between the first pair of words relatively difficult to grasp and the analogy relatively easy to fulfill.

Sample item:

1. electricity : energy : : green : ?
   A. color *B.* red *C.* grass *D.* trees *E.* foliage
2. athlete : scholar : : hands : ?
   A. seclusion *B.* write *C.* study *D.* book *E.* mind

Answers: 1–A, 2–E.

Scoring: $R - W/4$.

Parts, 2; items per part, 15; working time, 12 minutes; maximum score, 30.

11. Judgment

Test 49. Practical Judgment—CI301C. This is an Air Force test. It requires the

selection of the best solution to a wide range of problem situations, mostly in a military setting; the items are of the type commonly called "work-planning" items. The answers are selected from groups of four or five alternatives.

Scoring: $2R - W/3$, converted to stanine value.

Parts, 1; items per part, 30; working time, 30 minutes.

12. Visualization

Test 50. Mechanical Principles—CI9O3B. This is an Air Force Classification test in which all items are presented pictorially. The task consists in the application of mechanical principles to the pictured problems. *E* has to select the correct response among three to five choices. For example, two ways of extracting a nail from a board with a claw hammer are pictured, and the problem is to determine which of the two ways, if either, requires more force.

Scoring: $R - W/2 + 20$, converted to stanine value.

Parts, 1; items per part, 40; working time, 20 minutes.

13. Symbol Manipulation

Test 51. Symbol Manipulation. The items consist of a main statement composed of letters and symbols followed by several conclusions also stated in symbols. On the basis of the symbols given, *E* determines whether each of the conclusions is true or false in relation to the main statement.

Sample item:

"L" means "larger than"
"S" means "smaller than"
"E" means "equal to"
"NL" means "not larger than"
"NS" means "not smaller than"
"NE" means "not equal to"

If x S y (x is smaller than y), then:

1. x E y
2. x NL y
3. x L y

Answers: 1. False 2. True 3. False

Scoring: R – W.

Parts, 1; items per part, 25; working time, 7 minutes; maximum score, 25.

14. Numerical Facility

Test 52. Numerical Operations—CI7O2B. This is an Air Force Classification test consisting of two parts: Part I —deciding whether answers to simple addition and multiplication problems are right or wrong; Part II—finding the answer to simple subtraction and division problems. There are five choices.

Scoring: $R - 3W$, converted to stanine value.

Parts, 2; items per part, I–97, II–78; working time, I–5 minutes, II–5 minutes.

C. The Test Administration

The planning battery was administered to entering aircrew trainees at Lackland Air Force Base, Texas, in January 1954. The sample number for which scores were obtained on all the tests was 364. The test administration was reported to have run smoothly and the examinees were assumed to have worked at the tests with fairly high motivation. The Aircrew Classification Battery had been administered just prior to the experimental battery.

IV. Treatment of the Data

The classification tests were scored by the Air Force and scores converted to stanine values; the remaining tests were scored at this laboratory.

The test reliabilities were computed on a subsample of 200 examinees. The values and types of the reliability estimates are given in Table 1 along with

TABLE 1
MEANS, STANDARD DEVIATIONS, AND RELIABILITIES OF SCORES

Test	M	σ	r_{11}	Est.[a]
1. Matrix Order	14.6	4.2	.70	AF
2. Seeing Trends	9.7	4.5	.81	AF
3. Sensitivity to Order	13.0	2.1	.36	AF
4. Pertinent Questions	23.5	4.4	.80	AF
5. Awareness of Variables	9.9	2.1	.44	AF
6. Series	9.5	2.0	.44	KR
7. Effects	32.0	10.0	.84	AF
8. Consequences (remoteness)	9.7	4.4	.33	AF
9. Competitive Planning	19.1	6.8	.58	AF
10. Symbol Grouping	17.3	4.0	.65	AF
11. Contingencies	15.6	4.3	.69	AF
12. Route Planning	31.5	6.4	.77	AF
13. Planning Skills II	11.3	4.0	.73	AF
14. Planning Elaboration	15.5	4.1	.57	AF
15. Figure Production	23.9	7.7	.77	AF
16. Alternate Methods	11.4	2.5	.59	AF
17. Match Problems II	17.1	4.8	.65	AF
18. Symbol Production	26.2	8.6	.86	AF
19. Line Drawing	188.3	13.4	.63	AF
20. Temporal Ordering	37.5	11.8	.67	AF
21. Picture Arrangement	15.9	2.5	.60	AF
22. Sentence Order	11.4	2.6	.56	AF
23. Outlining (Part I)	12.6	3.5	.57	KR
24. Outlining (Part II)	10.6	3.8	.50	KR
25. Word Matrices	6.8	2.5	.79	OE
26. Unusual Methods	10.1	3.5	.74	AF
27. Verifications	28.3	6.2	.72	AF
28. Procedure Applications	10.5	4.8	.63	AF
29. Essential Operations	11.6	4.0	.62	AF
30. Ranking of Variables	59.8	8.8	.45	AF
31. Seeing Deficiencies	9.9	2.8	.58	AF
32. Planning Skills	13.0	4.0	.38	b[b]
33. Planning Air Maneuvers	5.2	2.4	.48	AF
34. Planning a Circuit	20.0	5.6	.73	AF
35. Code Analysis	15.0	7.5	.71	AF
36. G-Z Verbal Comprehension	20.6	6.2	.81	OE
37. Vocabulary	5.0	1.8	.83	TR-A
38. Ship Destination	6.5	3.3	.60	KR
39. Arithmetic Reasoning	5.6	1.7	.79	OE-A
40. Logical Reasoning	10.0	6.2	.58	AF
41. Inference	6.4	3.6	.67	AF
42. Plot Titles (cleverness)	6.4	3.7	.43	AF
43. Plot Titles (low quality)	12.2	6.9	.70	AF
44. Consequences (low quality)	13.1	4.8	.40	AF
45. Controlled Associations II	21.6	7.2	.67	AF
46. Match Problems	7.9	3.0	.56	AF
47. Sign Changes	21.6	4.5	.69	AF
48. Verbal Analogies I	12.3	4.4	.54	AF
49. Practical Judgment	5.4	1.9	.43	OE-A
50. Mechanical Principles	5.4	1.9	.82	OE-A
51. Symbol Manipulation	15.1	4.1	.48	KR
52. Numerical Operations	5.3	1.7	.81	AF-A

[a] AF: alternate-form estimate; OE: odd-even estimate; Spearman-Brown formula or Horst formula (where parts contained unequal numbers of items) was applied in AF and OE cases, except for tests 8, 42, 43, and 44; KR: Kuder-Richardson estimates; TR: Test-retest, A as a third letter refers to Air Force sources. The means and standard deviations of the Aircrew Classification tests were computed from stanine scores. The communality value is used as the lower-bound estimate of the reliability of test 32 because of the impossibility of making a valid estimate from what is essentially a single-item test.

the means and standard deviations of the tests.

Score distributions for most of the variables did not appear to be significantly deviant from normal and the raw scores were used in computing Pearson rs. The distributions of four of the variables (tests 12, 21, 42, 43) were markedly skewed. For these variables normalized scores were used in computing Pearson rs.

Two scores each were derived from the Plot Titles and Consequences tests, a low-quality and a cleverness score for the former, and a low-quality and a remoteness score for the latter. In the correlation of one score of a test with the other score of the same test, the two cross correlations of separately timed part scores were computed and averaged in order to arrive at a correlation value relatively uncontaminated by any experimental dependence of the two scores. For all other correlations in which these tests (Plot Titles and Consequences) were involved, the correlation coefficient used in the analysis was an average of those from two part scores. The correlation matrix is given in Table 2.

Seventeen centroid factors were extracted.[2] The highest coefficient in each column of the correlation matrix was used as the estimate of the communality of the corresponding variable. After each extraction the highest residual value in each column was used as an estimate of the communality remaining. The loadings of the last three centroid factors were all smaller than .20 but these factors were used in the later rotations in order to help clarify the other factors.

The Zimmerman graphic, orthogonal

[2] A copy of the centroid factor matrix has been deposited with the American Documentation Institute. Order Document No. 5269 from ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D.C., remitting in advance $1.25 for 35 mm. microfilm or $1.25 for 6 × 8 in. photocopies. Make checks payable to Chief, Photoduplication Service, Library of Congress.

method was used in rotating the axes (14). The criteria for rotations in the early stages were those of simple structure and positive manifold. Where these criteria were in conflict, the rotation was guided by the criterion of simple structure. After each axis had been rotated at least once, psychological meaningfulness and agreement with previous well-known factor-analytic results became important criteria. The final rotations were adjustive in nature in order to improve simple structure and positive manifold. The final rotated factor loadings are presented in Table 3.

V. Interpretation of the Factors

The factors are presented in the approximate order of their familiarity and definiteness. The interpretations rest principally upon those tests with loadings of .30 or greater. The test numbers, names, and factor loadings are listed preceding the discussion of each factor. In parentheses are loadings .30 or greater on other factors. Discussion of the reference factors is omitted except where the factor is relatively less well-known.

Factor A. Verbal Comprehension (V)

37	Vocabulary	.73
36	G-Z Verbal Comprehension	.71
41	Inference Test	.32 (.30 LE, .30 Or)
45	Controlled Associations II	.30

Factor B. Numerical Facility (N)

52	Numerical Operations	.66
47	Sign Changes	.51
39	Arithmetic Reasoning	.43 (.31 GR)

Factor C. Visualization (Vz)

50	Mechanical Principles	.44 (.32 AX)
12	Route Planning	.32 (.38 PF, .34 AX)

Factor D. General Reasoning (GR)

38	Ship Destination	.44
35	Code Analysis	.35 (.33 PF)
39	Arithmetic Reasoning	.31 (.43 N)
29	Essential Operations	.31 (.31 LE, .31 J)
23	Outlining (Part I)	.31

Factor E. Logical Evaluation (LE)

40	Logical Reasoning	.46
29	Essential Operations	.31 (.31 GR, .31 J)
41	Inference Test	.30 (.32 V, .30 Or)

Factor F. Ideational Fluency (IF)

44	Consequences (Low Quality)	.49
43	Plot Titles (Low Quality)	.37

The two tests listed for factor F were included in the battery primarily as reference tests for *ideational fluency*. The factor was previously defined (13) as the speed of calling up ideas in a situation in which there is relatively little restriction, and quality does not matter.

Factor G. Judgment (J)

31	Seeing Deficiencies	.46 (.36 Or)
11	Contingencies	.43 (.39 CF)
27	Verifications	.38
29	Essential Operations	.31 (.31 GR, .31 LE)
49	Practical Judgment	.30
14	Planning Elaboration	.30 (.44 E)

The *judgment* factor usually appears whenever "judgment" tests are included that are composed of items presenting a predicament and requiring the selection of the best solution. In the AAF analyses (9) the hypothesis offered for this factor was "the ability to weigh solutions and select the wisest and best one."

These results indicate that *judgment* is not bound to the multiple-choice test format. The individual himself can produce solutions prior to weighing the merits of solutions. A fluent recall of experiences that are relevant to the problem situation would provide the individual with a wide range of possible solutions from which to choose. In examining a number of solutions to a practical problem it is not unlikely that the best choice can be made when the examinee considers the given solutions against the background of his experience, placing them in a hierarchy of solutions that he produces.

TABLE 2

THE CORRELATION MATRIX[a]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1.		253	180	121	166	191	117	151	175	079	214	199	050	123	152	189	193	271	055	296	262	271	218	125	329	134
2.	253		137	232	138	264	273	219	171	065	266	132	121	226	144	223	173	299	168	251	157	251	169	216	248	223
3.	180	137		074	072	100	068	068	088	054	152	267	041	138	090	107	187	119	047	298	156	233	164	085	336	053
4.	121	232	074		170	132	626	340	062	036	482	163	467	465	257	516	136	316	023	214	160	219	065	223	141	409
5.	166	138	072	170		105	123	108	043	018	132	048	136	104	064	085	055	113	113	144	181	102	117	085	130	014
6.	191	264	100	132	105		162	167	167	128	105	146	049	130	166	220	195	263	128	256	206	201	151	131	285	086
7.	117	273	068	626	123	162		354	093	031	422	071	488	464	371	542	089	340	001	199	133	202	094	281	194	459
8.	161	219	068	340	108	167	354		121	050	332	066	292	345	214	342	038	248	082	164	122	188	128	211	190	300
9.	175	171	088	062	043	167	093	121		153	092	232	039	101	052	136	303	116	062	156	152	093	113	068	106	061
10.	079	065	054	036	018	128	031	050	153		088	160	062	037	024	107	170	024	−004	048	096	087	059	055	078	134
11.	214	266	152	482	132	105	422	333	092	088		055	354	372	230	398	138	279	068	245	092	292	140	285	252	303
12.	199	132	267	163	048	146	071	066	232	160	055		−065	039	016	121	372	134	128	248	266	110	094	040	202	071
13.	050	121	041	467	136	049	488	292	039	062	354	−065		479	287	336	−032	117	−014	093	023	168	095	200	164	344
14.	123	226	138	465	104	130	464	345	101	037	372	039	479		296	463	086	231	048	177	130	171	104	274	174	331
15.	152	144	090	257	064	166	371	214	052	024	230	016	287	296		290	056	280	024	156	204	163	056	172	106	304
16.	189	223	107	516	085	220	542	342	136	107	398	121	336	463	290		204	314	035	175	137	169	114	189	187	356
17.	193	173	187	136	055	195	089	038	303	170	138	372	−032	086	056	204		100	−012	182	231	119	092	022	185	−001
18.	271	299	119	316	113	263	340	248	116	024	279	134	117	231	280	314	100		132	310	151	201	166	177	196	292
19.	055	168	047	023	113	128	001	082	062	−004	068	128	−014	048	024	035	−012	132		148	084	177	−010	061	151	014
20.	296	251	298	214	144	256	199	164	156	048	245	248	093	177	156	175	182	310	148		261	323	154	186	305	129
21.	262	157	156	160	181	206	133	122	152	096	092	266	023	130	204	137	231	151	084	261		259	149	148	304	099
22.	271	251	233	219	102	201	202	188	093	087	292	110	168	171	163	169	119	201	177	323	259		166	187	342	086
23.	218	169	164	065	117	151	094	128	113	059	140	094	095	104	056	114	092	166	−010	154	149	166		200	146	147
24.	125	216	085	223	085	131	281	211	068	055	285	040	200	274	172	189	022	177	061	186	148	187	200		204	144
25.	329	248	336	141	130	285	194	190	106	078	252	202	164	174	106	187	185	196	151	305	304	342	146	204		047
26.	134	223	053	409	014	086	459	300	061	134	303	071	344	331	304	356	−001	292	014	129	099	086	147	144	047	
27.	242	285	169	376	186	202	421	292	060	−010	397	145	290	323	220	339	104	206	062	242	082	172	144	196	259	280
28.	234	266	171	338	194	198	437	282	034	−067	325	050	266	363	238	346	067	248	115	228	208	334	143	196	286	232
29.	264	254	227	158	269	204	213	222	198	067	271	187	120	191	029	213	215	105	084	268	136	282	163	250	347	063
30.	088	117	134	051	145	102	−006	063	035	−005	074	049	030	029	−079	045	088	050	089	093	123	058	087	088	197	−099
31.	358	287	178	375	230	185	296	240	103	076	350	168	202	282	181	333	170	212	032	281	255	364	226	266	302	164
32.	105	191	149	290	053	099	340	218	−034	044	306	−008	302	347	267	262	−032	246	023	149	082	257	170	133	117	344
33.	148	110	158	018	151	144	032	−016	189	057	016	240	−034	016	016	098	284	114	−005	226	080	155	090	090	166	−040
34.	120	120	152	153	037	206	151	104	194	118	094	317	037	102	084	142	256	096	002	086	224	109	020	−009	152	149
35.	230	112	146	018	110	192	058	110	294	178	044	215	035	108	−021	152	303	080	057	221	147	171	248	132	261	041
36.	276	294	225	188	276	186	248	200	035	−045	301	096	145	200	081	163	052	172	189	328	124	389	155	229	290	028
37.	286	336	218	209	219	137	243	216	049	−050	404	056	170	198	151	142	010	235	211	369	126	416	135	220	349	055
38.	203	248	230	104	148	319	119	166	258	072	151	252	105	123	045	046	181	084	174	191	264	265	192	123	292	113
39.	235	278	273	076	200	128	143	154	171	002	170	280	060	107	038	175	251	124	020	255	129	201	266	200	290	−039
40.	210	283	230	162	238	203	177	160	120	019	122	245	044	178	051	208	188	066	065	238	146	262	103	147	298	−002
41.	316	314	195	253	226	160	288	230	116	026	332	191	158	195	190	254	181	217	127	324	255	342	148	209	357	176
42.	100	232	115	253	134	127	288	291	080	−084	244	034	174	245	241	274	019	276	088	184	092	160	126	180	160	186
43.	−012	022	−103	286	−076	016	294	140	081	114	158	−026	270	284	178	204	015	098	016	−014	013	−034	034	100	−087	252
44.	009	062	022	252	034	029	304	240	−034	050	184	−039	243	248	205	244	082	140	032	036	013	020	020	040	014	216
45.	196	261	218	308	075	172	424	232	088	049	321	060	234	292	198	319	114	208	106	218	−004	234	113	186	206	188
46.	162	165	183	098	089	254	087	078	277	115	047	395	−054	050	161	130	455	111	−010	228	263	108	133	082	219	077
47.	115	213	075	085	−048	148	106	133	123	130	180	148	012	073	047	120	068	192	101	160	071	130	144	122	184	069
48.	301	196	368	169	153	224	183	168	122	064	205	170	179	186	118	213	201	116	044	264	198	286	188	208	382	−005
49.	195	105	196	129	112	023	087	048	−027	−017	106	164	043	078	070	045	154	110	093	175	129	216	−006	056	183	008
50.	127	127	249	070	132	136	028	−028	047	−016	008	249	051	−029	−047	040	152	100	−026	090	−089	039	028	011	068	−027
51.	160	047	139	040	048	115	072	058	114	003	−035	105	−015	059	−004	086	115	035	−021	177	099	168	128	008	124	−055
52.	084	142	071	102	007	075	135	196	188	123	152	150	094	138	017	132	184	068	042	152	031	118	081	234	142	070

[a] Decimal points have been omitted.

Factor H. Eduction of Conceptual Relations (CR)

48	Verbal Analogies I	.47
3	Sensitivity to Order	.46

This factor emerged in the two reasoning studies (3, 6). In both of those analyses, Verbal Analogies I was the leading test. The test was specifically designed to emphasize the discovery of meaningful relationships, and the interpretation of the factor was based upon this intent.

The discovery feature is certainly important in Sensitivity to Order also. In this test adjustments in the given orders of words are to be made when one of the words is seen to be out of order. Although the emergence of factor H in

TABLE 2 (*Continued*)

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
242	234	264	088	358	105	148	120	230	276	286	203	235	210	316	100	−012	009	196	162	115	301	195	127	100	084	1.
285	266	254	117	287	191	110	120	112	294	336	248	278	283	314	232	022	062	261	165	213	196	105	127	047	142	2.
169	171	227	134	178	149	158	152	146	225	218	230	273	230	195	115	−103	022	218	183	075	368	196	249	139	071	3.
376	338	158	051	375	290	018	153	018	188	209	104	076	162	253	253	286	252	308	098	085	169	129	070	040	102	4.
186	194	269	145	230	053	151	037	110	276	219	148	200	238	226	134	−076	034	075	089	−048	153	112	132	048	007	5.
202	198	204	102	185	099	144	206	192	186	137	319	128	203	160	127	016	029	172	254	148	224	023	136	115	075	6.
421	437	213	−006	296	340	032	151	058	248	243	119	143	177	288	288	294	304	424	087	106	183	087	028	072	135	7.
292	282	222	063	240	218	−016	104	110	200	216	166	154	160	230	291	140	240	232	078	133	168	048	−028	058	196	8.
060	034	198	035	103	−034	189	194	294	035	049	258	171	120	116	080	081	−034	088	277	123	122	−027	047	114	188	9.
−010	−067	067	−005	076	044	057	118	178	−045	−050	072	002	019	026	−084	114	050	049	115	130	064	−017	−016	003	123	10.
397	325	271	074	350	306	016	094	044	301	404	151	170	122	332	244	158	184	321	047	180	205	106	008	−035	152	11.
145	050	187	049	168	−008	240	317	215	096	056	252	200	245	191	034	−026	−039	060	395	148	170	164	249	105	150	12.
290	266	120	030	202	302	−034	037	035	145	170	105	060	044	158	174	270	243	234	−054	012	179	043	051	−015	094	13.
323	363	191	029	282	347	016	102	108	200	198	123	107	178	195	245	284	248	292	050	073	186	078	−029	059	138	14.
220	238	029	−079	181	267	016	084	−021	081	151	045	038	051	190	241	178	205	198	161	047	118	070	−047	−004	017	15.
339	346	213	045	333	262	098	142	152	163	142	046	175	208	254	274	204	244	319	130	120	213	045	040	086	132	16.
104	067	215	088	170	−032	284	256	303	052	010	181	251	188	181	019	015	082	114	455	068	201	154	152	115	184	17.
206	248	105	050	212	266	114	096	080	172	235	084	124	066	217	276	098	140	208	111	192	116	110	100	035	068	18.
062	115	084	089	032	023	−005	002	057	189	211	174	020	065	127	088	016	032	106	−010	101	044	093	−026	−021	042	19.
242	228	268	093	281	149	226	086	221	328	369	191	255	238	324	184	−014	036	218	228	160	264	175	090	177	152	20.
082	208	136	123	255	082	080	224	147	124	126	264	129	146	255	092	013	013	−004	263	071	198	129	−089	099	031	21.
172	334	282	058	364	257	155	109	171	389	416	265	201	262	342	160	−034	020	234	108	130	286	216	039	168	118	22.
144	143	163	087	226	170	090	020	248	155	135	192	266	103	148	126	034	020	113	133	144	188	−006	028	128	081	23.
196	196	250	088	266	133	090	−009	132	229	220	123	200	147	209	180	100	040	186	082	122	208	056	011	008	234	24.
259	286	347	197	302	117	166	152	261	290	349	292	290	298	357	160	−087	014	206	219	184	382	183	068	124	142	25.
280	232	063	−099	164	344	−040	149	041	028	055	113	−039	−002	176	186	252	216	188	077	069	−005	008	−027	−055	070	26.
	365	286	140	302	223	096	148	065	330	310	156	237	289	284	204	138	086	318	118	064	260	147	305	031	−016	27.
365		229	098	380	282	065	122	041	324	356	167	234	280	309	250	169	150	378	086	096	186	225	032	132	122	28.
286	229		088	376	119	179	097	286	358	343	325	371	402	288	102	−009	−032	180	154	169	356	245	188	216	226	29.
140	098	088		089	039	059	008	142	178	130	193	144	169	126	068	−134	102	096	034	063	121	154	117	084	049	30.
302	380	376	089		257	188	232	155	399	381	285	281	284	374	132	004	048	304	156	063	334	299	106	122	086	31.
223	282	119	039	257		−016	062	−001	217	249	133	047	059	171	179	148	223	250	007	093	128	105	−103	073	021	32.
096	065	179	059	188	−016		215	240	097	109	145	257	250	156	054	−088	−068	060	378	122	181	093	240	109	060	33.
148	122	097	008	232	062	215		110	078	074	172	060	−005	130	026	−008	−002	054	258	078	084	117	182	093	−007	34.
065	041	286	142	155	−001	240	110		090	050	302	325	238	152	070	038	−048	052	233	220	282	−013	098	122	310	35.
330	324	358	178	399	217	097	078	090		782	243	327	325	447	144	−109	−042	398	119	089	473	300	166	297	088	36.
310	356	343	130	381	249	109	074	050	782		240	295	245	456	162	−074	−023	414	102	130	357	273	069	212	162	37.
156	167	325	193	285	133	145	172	302	243	240		246	323	205	124	−074	−087	174	200	142	299	124	163	170	169	38.
237	234	371	144	281	047	257	060	325	327	295	246		360	302	115	−048	−003	263	262	259	372	135	122	209	399	39.
289	280	402	169	284	059	250	−005	238	325	245	323	360		370	114	−076	−034	147	240	106	379	178	238	192	129	40.
284	309	288	126	374	171	156	130	152	447	456	205	302	370		187	031	032	244	180	155	326	194	055	147	164	41.
204	250	102	068	132	179	054	026	070	144	162	124	115	114	187		058	088	187	109	099	129	014	−012	036	099	42.
138	169	−009	−134	004	148	−088	−008	038	−109	−074	−074	−048	−076	031	058		292	095	−052	052	−117	−060	−153	−079	113	43.
086	150	−032	102	048	223	−068	−002	−048	−042	−023	−087	−003	−034	032	088	292		188	021	090	052	−013	−048	−023	017	44.
318	378	180	096	304	259	060	054	052	398	414	174	263	147	244	187	095	188		100	057	306	202	079	154	139	45.
118	086	154	034	156	007	378	258	233	119	102	200	262	240	180	100	−052	021	100		048	247	128	176	114	120	46.
064	096	169	063	063	093	122	078	220	089	130	142	259	106	155	099	052	090	057	048		093	000	−101	140	425	47.
260	186	356	121	334	128	181	084	282	473	357	299	372	379	326	129	−117	052	306	247	093		185	260	228	089	48.
147	225	245	154	299	105	093	117	−013	300	273	124	135	178	194	014	−060	−013	202	128	000	185		186	007	−002	49.
305	032	188	117	106	−103	240	182	008	166	069	163	122	238	055	−012	−153	−048	079	176	−101	260	186		018	−220	50.
031	132	216	084	122	073	100	093	122	297	212	170	209	192	147	036	−079	−023	154	114	140	228	007	018		118	51.
−016	122	226	049	086	021	060	−007	310	088	162	169	399	129	164	099	113	017	139	120	425	089	−002	−220	118		52.

this analysis lends confirmation to the existence of this ability, the definition has not been clarified, due to the paucity of tests with loading on the factor.

Factor I. Originality (O)

18	Symbol Production	.42
42	Plot Titles (Cleverness)	.36
2	Seeing Trends	.35
8	Consequences (Remoteness)	.34 (.30 CF)
26	Unusual Methods	.32 (.34 E)
15	Figure Production	.30 (.37 E)

This seems to be the *originality* factor that emerged in the analysis of creative-thinking tests. In that study, Plot Titles was the leading test on *originality*, and Consequences also had a significant loading.

Symbol Production was designed as a

TABLE 3

ROTATED FACTOR LOADINGS

	A V	B N	C Vz	D GR	E LE	F IF	G J	H CR	I O	J PF	K AX	L Or	M E	N CF	O (r)	P (r)	Q (r)	h^2
1.	.03	−.02	−.09	.11	.17	.00	.29	.22	.17	.12	.12	.33	−.12	.01	−.12	.06	.04	.39
2.	.15	.17	.14	.19	.11	.04	.23	.00	.35	.06	.11	.14	.02	.04	−.08	.08	−.07	.35
3.	.03	.11	.24	.03	.05	−.06	.10	.46	.02	.01	.09	.24	.12	−.05	.01	−.10	.07	.40
4.	.06	.03	.08	.02	.03	.24	.27	−.10	.11	.07	.09	.14	.28	.58	.00	−.02	−.17	.65
5.	.18	−.08	.02	.26	.24	.06	.09	−.06	.08	−.08	.13	.15	−.12	.10	.10	−.08	−.07	.28
6.	−.03	−.02	.07	.25	−.03	.00	.00	.12	.28	.18	.15	.24	.05	.02	−.02	.16	−.15	.33
7.	.04	.08	−.03	.09	.06	.26	.28	−.03	.17	.01	.07	.09	.47	.46	−.04	.13	−.13	.68
8.	.06	.11	−.01	.10	.14	.09	.14	.02	.34	.14	−.05	.06	.19	.30	−.01	−.02	.05	.34
9.	−.01	.16	−.01	.24	.01	−.01	−.03	.00	.06	.40	.18	.07	.02	.00	.03	.10	.03	.30
10.	−.08	.06	−.06	−.02	−.06	.08	.09	.08	.03	.36	.08	−.02	−.08	.00	.08	−.14	−.09	.22
11.	.19	.18	.03	.00	−.08	.03	.43	.02	.23	.08	−.06	.14	.13	.39	.09	−.06	−.01	.53
12.	−.02	.16	.34	−.06	.17	.00	.03	.13	−.05	.38	.34	.17	−.02	.00	−.15	−.02	−.02	.51
13.	.06	−.02	−.07	.15	.02	.22	.23	−.03	.07	.05	−.14	.03	.40	.31	.19	−.16	−.06	.49
14.	.00	.05	.05	.11	.12	.26	.30	−.04	.19	.12	−.09	.08	.44	.19	.21	−.03	−.03	.53
15.	−.02	−.06	−.09	−.09	.07	.14	.15	.02	.30	.00	.12	.17	.37	.05	.04	.02	.02	.34
16.	−.06	.08	−.07	.01	.13	.18	.24	.11	.18	.13	.10	.11	.26	.44	.09	.16	−.05	.51
17.	−.01	.18	.11	.07	.00	.14	.03	.09	−.10	.32	.43	.21	−.09	.05	.11	.10	.16	.47
18.	−.06	.09	.00	−.04	.00	.06	.10	.06	.42	−.01	.15	.24	.09	.15	−.16	.19	−.19	.41
19.	.15	.04	.19	.02	.03	.09	−.06	−.01	.26	.07	−.14	.12	−.08	−.08	−.01	.05	−.13	.21
20.	.15	.19	.05	.07	.08	.02	.11	.18	.30	.06	.14	.36	.04	.00	−.02	−.01	−.17	.34
21.	.02	−.12	.03	.04	.19	.07	−.04	−.04	.09	.23	.12	.53	.03	.02	−.12	−.06	.10	.44
22.	.27	.10	.03	.06	.03	.00	.15	.17	.11	.07	−.04	.45	.10	.03	−.01	−.13	−.18	.42
23.	−.04	.12	−.15	.31	−.01	.00	.16	.13	.11	.02	.08	.14	.02	−.02	−.10	−.14	.06	.25
24.	.03	.21	−.04	.19	.10	.02	.26	−.05	.14	.01	−.09	.30	.12	.04	.12	.01	−.03	.26
25.	.11	.11	.16	.13	.12	−.07	.10	.26	.14	.14	−.04	.44	.02	.07	.07	−.01	−.02	.41
26.	−.08	−.02	−.06	−.04	−.01	.10	.28	−.06	.32	.16	.11	−.06	.34	.23	−.16	−.20	−.05	.49
27.	.08	−.04	.20	.23	.12	.00	.38	.13	.15	−.03	.10	.04	.23	.20	−.04	.12	−.06	.44
28.	.18	.03	.05	.12	.16	.20	.33	.04	.13	−.10	−.02	.32	.29	.17	−.15	.07	.01	.44
29.	.16	.16	.08	.31	.31	−.07	.31	.16	−.04	.18	.02	.14	−.03	.06	.00	−.03	−.12	.45
30.	.08	.03	.33	.35	−.02	.10	−.04	.08	.09	−.09	.00	.13	−.24	.13	.06	−.08	.12	.28
31.	.21	−.02	−.05	.15	.15	.04	.46	.08	−.01	.09	.09	.36	.02	.17	−.06	−.05	.02	.50
32.	.11	.00	−.07	.03	−.07	.22	.23	.13	.24	−.06	−.02	.07	.39	.09	−.12	−.26	−.03	.38
33.	.04	.18	.06	.14	.03	−.12	.05	.05	−.07	.02	.47	.19	−.02	−.08	.14	−.02	−.13	.38
34.	.08	−.08	.22	.02	−.08	−.09	.07	.04	−.10	.39	.35	.21	.03	−.02	−.15	.03	.02	.44
35.	−.12	.25	−.13	.35	.14	−.05	−.01	.18	.00	.33	.10	.18	−.07	−.03	.12	−.07	−.02	.44
36.	.71	.04	.02	.30	.17	.00	.24	.28	.12	−.02	−.03	.14	.03	.02	−.03	.12	−.14	.70
37.	.73	.16	.00	.09	.04	−.03	.29	.17	.22	−.03	−.08	.21	.05	−.02	−.05	.08	−.09	.80
38.	.13	.01	.24	.44	.08	−.08	.00	.13	.11	.20	.00	.20	.00	−.01	−.14	−.17	.02	.49
39.	.11	.43	.00	.31	.25	.00	.16	.31	−.06	−.02	.15	.16	.00	−.01	−.04	.07	.14	.31
40.	.14	.14	.21	.28	.46	−.05	.04	.21	−.02	−.07	.14	.15	.03	.12	.04	−.01	−.10	.50
41.	.32	.12	.01	.03	.30	−.01	.18	.11	.17	.06	.11	.30	.04	.16	−.02	−.01	−.03	.42
42.	.01	.12	.01	.09	.05	−.07	.02	−.02	.36	−.10	.01	.16	.23	.20	.03	.03	.09	.30
43.	−.16	.08	−.12	−.03	.00	.37	.09	−.18	.04	.13	−.07	−.10	.27	.09	.01	.02	−.11	.35
44.	−.09	.02	−.02	−.08	−.04	.49	.01	.09	.16	−.06	.01	−.06	.08	.23	.09	−.06	.02	.37
45.	.30	.10	.02	.10	−.08	.23	.27	.28	.10	−.02	−.01	.07	.21	.16	−.01	.18	.07	.45
46.	.04	.12	.09	.07	.08	−.01	−.04	.09	.04	.23	.57	.19	.10	−.08	.10	.06	.15	.51
47.	−.04	.51	−.04	.03	.04	.05	−.01	.09	.17	.12	−.04	.06	−.06	.02	−.20	−.03	−.12	.30
48.	.18	.05	.07	.23	.19	−.04	.16	.47	−.01	.08	.04	.23	.05	.06	.18	.04	−.03	.48
49.	.22	−.03	.25	−.07	.12	.14	.30	.09	−.07	−.06	.06	.21	−.08	−.09	−.03	−.02	.06	.33
50.	−.04	−.12	.44	.16	.00	−.18	.23	.20	−.10	−.09	.32	−.10	−.08	.02	.03	.18	−.18	.56
51.	.22	.08	−.15	.18	.10	−.02	−.15	.28	−.10	.05	.09	.08	.03	.05	−.22	.03	−.04	.30
52.	.08	.66	−.10	.09	.17	.06	−.01	−.03	.01	.24	−.10	.01	.04	.00	−.01	−.04	.08	.57

test of symbolic thinking, along with the Line Drawing test (8). Both tests had their highest loading on *originality*, although in the case of the Line Drawing test, which had a very low communality, the loading is only near-significant (.26). Apparently the invention of symbols involves originality as much as those tests that call for clever, remote, and uncommon responses.

An interesting paradox may be noted in that the Line Drawing and the Symbol Production tests were scored on the basis of *commonness* (in the former test) and *intelligibility* (in the latter) of the symbols. Seemingly, a similar psychological process is demonstrated in one type of test resulting in uncommon responses, and in other tests resulting in responses that are common and readily understood.

Perhaps the conception of the factor of *originality* needs to be broadened to include symbolizing activities. The production of symbols of the kinds involved in tests 18 and 19 may be a sufficiently uncommon act in itself to require originality, so that the scoring can stress common responses and yet measure *originality*. In any event, Symbol Production emerges in this study as a very promising test of *originality*.

Factor J. Perceptual Foresight (PF)

9	Competitive Planning	.40
34	Planning a Circuit	.39 (.35 AX)
12	Route Planning	.38 (.34 Vz, .34 AX)
10	Symbol Grouping	.36
35	Code Analysis	.33 (.35 GR)
17	Match Problems II	.32 (.43 AX)

This factor seems to involve the ability to explore visually possible courses of action in order to select the most effective ones for getting solutions to detailed visual problems. Competitive Planning, Route Planning, and Symbol Grouping were selected or designed as measures of foresight. Each of these tests presents a task in which, ostensibly, several alternative courses may be pursued to the goal. Only one of the courses, however, is considered to fulfill the criterion given. In each case the examinee must look well beyond the step at which he is working in order to select the proper course of action. The steps or moves that are most obvious or seem to provide immediate gains are not always the best in terms of future gains or in leading to a correct solution.

Factor K. Adaptive Flexibility (AX)

46	Match Problems	.57
33	Planning Air Maneuvers	.47
17	Match Problems II	.43 (.32 PF)
34	Planning a Circuit	.35 (.39 PF)
12	Route Planning	.34 (.34 Vz, .38 PF)
50	Mechanical Principles	.32 (.44 Vz)

This has been identified as *adaptive flexibility*, principally on the basis of Match Problems, which served as a reference test for this factor. The presence of three Air Force planning tests on this factor might suggest that this is the Air Force planning factor. It is much easier to rationalize these tests as flexibility tests, however, than to rationalize Match Problems as a planning test. This suggests that the Air Force planning factor was indeed *adaptive flexibility*. Another possibility is that the two factors have telescoped into one, but we prefer the interpretation stated first.

Adaptive flexibility was defined in the creativity study (13) as the ability to change set to meet new requirements imposed by changing problems. In an unpublished study in collaboration with the Institute of Personality Assessment and Research at Berkeley there was evidence of a further generality of *adaptive flexibility* in the significant loadings of two tests that required perceptual analysis and perceptual reorganization prior to solution. In that study it was also indicated that problem solving requiring insights may in general depend on the ability to shift set.

In all the tests in the above list some type of visual restructuring in order to solve a problem seems to be a common feature. Not only is the examinee required to do visual restructuring but he must also reorganize perceptually the same material in different ways to meet different requirements. In the Match Problems test, some of the problems are impossible of solution unless the examinee breaks a self-imposed instructional set. In Planning Air Maneuvers, frequently the same or similar letter configurations are used but the differences in the start and end positions among these configurations require the examinee to find new patterns.

Factor L. Ordering (Or)

21	Picture Arrangement	.53
22	Sentence Order	.45
25	Word Matrices	.44
20	Temporal Ordering	.36
31	Seeing Deficiencies	.36 (.46 J)
1	Matrix Order	.33
28	Procedure Applications	.32
41	Inference Test	.30 (.32 V, .30 LE)

This is the hypothesized *ordering* factor. Tests 21, 22, 25, 20, and 1 all require some indication of the correct arrangement of objects or events. The three tests constructed or adapted to measure the temporal aspect of ordering, Picture Arrangement, Sentence Order, and Temporal Ordering, all had significant loadings. Of the three tests that called for the hierarchical arrangement of subject matter, Outlining I and II and Word Matrices, only Word Matrices was weighted significantly.

In the two leading tests, Picture Arrangement and Sentence Order, a temporal arrangement of events is required in order to make a sensible story. In Picture Arrangement, the events are presented pictorially; in Sentence Order, the events are in language form. These two tests were involved in Adkins' reasoning study (1). In order to explain their significant loadings on a *verbal* factor in that study, it was suggested that *verbal comprehension* would be more suitably named *verbal relations* where "perception and manipulation of verbal relations" is emphasized rather than just the knowledge of word meanings. The present analysis, with the increased number of ordering tests, has effected a separation between the *verbal-comprehension* factor, defined by vocabulary tests, and *ordering*, defined by tasks in which manipulation of relations is required.

Consideration of the tests listed above leads to the interpretation of *ordering* as the ability to arrange objects or events, or to define an arrangement of objects or events, in a sequence that is meaningful either in terms of time, hierarchical, or causal relationship.

Factor M. Elaboration (E)

7	Effects	.47 (.46 CF)
14	Planning Elaboration	.44 (.30 J)
13	Planning Skills II	.40 (.31 CF)
15	Figure Production	.37 (.30 O)
26	Unusual Methods	.34 (.32 O)

This is the elaboration factor hypothesized to be involved in tasks requiring the specification of details that would contribute to the development of an idea or to the variations of an idea.

In both Planning Elaboration and Planning Skills II, the verbal specification of details was called for in the development of plans or activities. The significant loading of Figure Production on this factor indicates that *elaboration* seems to be common to both figural and verbal tasks. In the Figure Production test, the examinee is required to produce a meaningful figure out of an ambiguous marking. The figures produced were scored for the degree of elaborateness; that is, the more detail the examinee puts in, the higher his score.

The significant loadings of the Effects test on this factor, a test in which the examinee lists four future effects of a given present trend, and of the Unusual Methods test, which calls for different ways of handling given problems, indicate that idea development can be carried on in terms of variations of an idea that show its range or scope.

Factor N. Conceptual Foresight (CF)

4	Pertinent Questions	.58
7	Effects	.46 (.47 E)
16	Alternate Methods	.44
11	Contingencies	.39 (.43 J)
8	Consequences (Remoteness)	.30 (.34 O)

The tests with significant loadings on

this factor seem to require the examinee to envision a problem situation in such ways that needs or consequences are anticipated. In tests 4 and 11 the examinee must be aware of or anticipate the needs in a situation. In tests 7 and 8 he must see the more remote consequences connected with hypothetical happenings.

The leading test on factor N, Pertinent Questions, was constructed as an orientation task in which the examinee must, by asking many different questions, show an awareness of the variables present in the situation. This was a decision-making task in which very little information was provided. The task proved to be more than an awareness process; the examinee apparently conceptualized the variable in terms of the needs he foresaw in the situation.

The Effects test was devised as a test of extrapolation, and, along with the Consequences test, was scored for remoteness. These two tests require the examinee to think of various features of the situation in terms of which the effects or consequences could be indicated. This is a task involving foresight.

Factors O, P, and Q were not defined by any loadings greater than .30, and were considered residual factors.

VI. Discussion

The formulation of the hypotheses of the abilities necessary to planning performances was made in terms of the classes of planning activities and in terms of the qualitative aspects of planning. It was felt that planning could not be adequately investigated as a unitary psychological function but must be broadly conceived as a term covering a number of classes of activities and entailing a number of separate abilities. It was hypothesized that as planning proceeds through certain stages or when different aspects of planning are emphasized, different abilities are called upon, either consecutively or in combination.

A. Relation of Obtained Factors to Initial Hypotheses

The hypothesis of orientation as an activity necessary not only to planning performance but to problem-solving in general did not correspond to any one of the previously found factors or to any new ability. Orientation remains only a descriptive term for those activities that involve the seeing of an order or trend in a mass of information and that show an awareness of the pertinent variables operating in a situation. Tests of the two subhypotheses of orientation are loaded variously on factors of *ordering, originality, eduction of conceptual relations,* and *conceptual foresight.*

The futuristic character of planning performance was hypothesized to call upon a predictive ability. Tests of prediction were constructed in terms of two variations of prediction: extrapolation and foresight. For each of these variations, both perceptual and conceptual tests were included in the analysis. A separation occurred in terms of this distinction rather than between extrapolation and foresight. Competitive Planning, Symbol Grouping, and Route Planning, designed as perceptual tests involving foresight, emerged on *perceptual foresight.*

The finding of a *perceptual-foresight* factor, which is defined in part by maze tests, is in accordance with C. D. Porteus' belief that the maze tests he used were tasks involving foresight (12). Porteus implied that there is more than one level of foresight or planning, i.e., that there is a low-level kind, as typified by the ability called upon in solving the mazes,

and a more abstract or high-level kind, as called for in creative work, and that it is necessary to be capable of the lower-level foresight before one can exhibit the higher-level type. The results of this study would seem to confirm the existence of more than one kind of foresight. *Perceptual foresight* and *conceptual foresight,* however, were found as distinct factors, indicating that one type of foresight is not necessarily basic to the other.

The three conceptual tests constructed to measure the predictive ability helped to define the *conceptual-foresight* factor. Foresight in this study has been viewed as an awareness of possible future events that have a relation to a present situation. This definition of foresight appears to involve the flexibility of ideas, as indicated by the fact that the examinee has to conceptualize different needs that might be connected with the given situation in order to answer the problem in the foresight tests.

The results do not seem to support the subhypothesis of extrapolation as one type of task involving a predictive ability. The Series test, intended as a perceptual task requiring extrapolation, was not significantly weighted on any of the factors in this analysis. As indicated in the interpretation of the *conceptual-foresight* factor, the Effects test and Consequences could be characterized more as tests of foresight than of extrapolation because of the additional information required in order to give suitable responses.

Due to the multiple-response characteristic of most of the *conceptual-foresight* tests, it is not clear to what extent response fluency enters into the factor. It remains for future study to clarify this aspect of the factor.

The identification of a factor of *elaboration* was based upon the significant loadings of the tests connected with the subhypothesis of specification. It is an interesting finding that *elaboration* is not confined to verbal tests, as is indicated by the presence of a figural test on this factor. Apparently the ability to elaborate in a figural task is related to the ability to specify details in a verbal task. Had there been more alternate tests requiring perceptual elaboration, however, a factor for such tests might have been split off from one for conceptual elaboration.

The significant loading of the Effects test on this factor indicated that the factor should be described not only in terms of specifying details in order to develop an idea but also in terms of the production of variations of an idea which serve to show the scope of the idea.

Some comment should be made about the subhypothesis of symbolization. The elaboration factor apparently does not encompass the symbolic representation of ideas; neither does the symbolization subhypothesis define a separate symbolization factor. The expected high correlation between the two tests, Symbol Production and Line Drawing, did not materialize. The variances of these two tests were accounted for principally by the *originality* factor.

The confirmation of an *ordering* factor is indicated by the significant loadings for tests that contained items requiring the ordering of bits of information in temporal, causal, and logical sequences.

The tests designed to measure thinking ingenuity in relation to planning tasks did not serve to determine a factor of ingenuity. Much of the variance on these tests, particularly that of Unusual Methods, was accounted for by the

originality factor. There was a question whether *originality*, defined in terms of unconventionality of thinking in the creativity study, would be important in planning tasks where new procedures, or applications of old procedures to new situations, must be devised. Admittedly the hypothesis of ingenuity was not satisfactorily tested in some respects. There were too few tests representing this hypothesis, and it might have been better if the experiential features in these tests had been reduced.

Two of the three tests designed to measure the evaluation aspects of planning emerged on the *judgment* factor.

B. Relation of Results to Factors in Previous Studies

Twenty tests were included in the planning battery for fourteen reference factors. Only three of the reference factors, *associational fluency*, *symbol manipulation*, and *integration III*, did not emerge in some form in the analysis. Tests of the *planning* factor found in the AAF analyses, and of *adaptive flexibility*, isolated in the creativity study, emerged together on a single factor (*adaptive flexibility*). This result helps to clear up to some degree the question regarding the essential ability represented by the AAF *planning* factor. It also broadens the conception of *adaptive flexibility*.

The results of this study were also informative with regard to the natures and scopes of certain other reference factors. *Judgment* was found to be weighted in various completion-type tests as well as tests with a multiple-choice format. The factor of *ideational fluency* seems to apply better to tasks in which responses are produced under fairly unrestricted conditions and involve responses that arise from the more superficial aspects of situations.

A new test, Symbol Production, seems to provide a good measure of the *originality* factor, previously isolated in connection with the creative-thinking battery, and indicates a possible symbolic aspect of *originality*.

Elaboration, *ordering*, *perceptual foresight*, and *conceptual foresight* are regarded as new factors, but we should consider their possible relations to previously known factors. The verification of these factors, of course, will depend on future research. *Elaboration* may represent a new and more significant dimension of *ideational fluency*. The factor interpreted as *perceptual foresight* might alternatively be identified as the *integration III* factor found in the AAF analyses, since several of the tests that helped to define the latter factor were loaded significantly on factor J of this study. However, the leading test on *integration III*, Planning Air Maneuvers, was included in this study but did not have a significant loading on factor J. In view of this and of the fact that three tests designed to measure foresight had significant loadings on factor J, it was felt that this factor would be better characterized as *perceptual foresight*.

Conceptual foresight bears some resemblance to the *spontaneous-flexibility* factor identified in the creative-abilities study, but the idea flexibility involved in *conceptual foresight* is more purposive, or goal-directed.

C. Relation of Results to the General Planning Test

The Lorge test of Planning Skills (test 32) was included in the analysis as a general planning task. Given a detailed account of a practical problem situation

the examinee had to define and structure the problem for himself, find the critical areas, perhaps evaluate the alternate methods he thought of, and write down all the steps necessary for carrying out the procedures adopted. Because of the complexity of the task a number of abilities were considered to be involved.

The Planning Skills test was treated as any other variable in the analysis and no special attention was given it in the rotations of the axes. Results from the preliminary testing with two problems (only one problem situation was used in the final battery) had yielded an alternate-forms estimate of about .40. If this is a reasonable estimate, practically all of the true variance was accounted for in terms of common factors by this study. Since the factor loadings are all very low, however, our conclusions as to factor content are merely suggestive; certainly not decisive.

As expected, the common-factor variance represents a number of factors. The leading factors and the proportions of common-factor variance that each accounts for are as follows (these proportions add up to 1.00):

Factor	M.	Elaboration	.22
Factor	I.	Originality	.15
Factor	G.	Judgment	.14
Factor	F.	Ideational Fluency	.12
Factor	P.	(Residual)	.18
		(Others)	.19

The Planning Skills test called for considerable detail in the examinee's report of a plan, hence the *elaboration* variance. Responses were scored to some extent for quality, therefore the production of clever and uncommon ideas would be likely to receive weight and thus introduce variance in *originality*. The contribution of the factor *judgment* can be rationalized by supposing that the examinee had to select critically the significant features of the problem, to evaluate the hypotheses and ideas that came up, and to maintain continual check on the internal consistency of his plan. The weight in *ideational fluency* probably reflects the fact that quantity of ideas was weighted in the scoring. As indicated before, these small contributions may not be very accurately estimated. It should also be remembered that the Lorge test represents only one kind of planning.

VII. Summary

The purpose of this study was to isolate and define the abilities involved in planning. A battery of 52 tests covering six hypotheses and a number of reference factors was administered to 364 USAF aircrew trainees. Included in the battery was one test that represented a general planning activity. The scores were intercorrelated and 17 factors were extracted. Orthogonal rotations resulted in 14 identifiable factors, ten of which had been found previously: *verbal comprehension, numerical facility, visualization, general reasoning, logical evaluation, ideational fluency, eduction of conceptual relations, judgment, originality,* and *adaptive flexibility.* Four new factors were defined as *ordering, elaboration, perceptual foresight,* and *conceptual foresight.* The greatest proportions of the common-factor variance of the general planning test were contributed by the factors of *elaboration, originality, judgment,* and *ideational fluency.*

It may be said that this investigation supports the hypothesis that in planning we should find a large number of primary abilities involved. Of the factors found in this investigation, four are new and seem to be unique to planning tests. They are the abilities of *ordering, elaboration, perceptual foresight,* and *conceptual foresight.*

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